# TEXTILE RESEARCH

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# Program for Annual Meeting

YOUR committee on arrangements for the seventh annual meeting has prepared programs for the dinner and research conference which should attract an even larger attendance of members and guests than was present a year ago. Reservations received at this writing indicate that the holding of the meeting two days after the national election promises to stimulate attendance, because of the large number of mill men who are planning to be in New York on that date for business reasons. They can have the morning of Nov. 5 for business, and attend the research conference at 2 P. M., and the dinner in the evening. Manufacturers and selling agents who may find it difficult to attend the daytime sessions, can make no better investment of time and money than by enjoyment of the dinner and its speaking program.

### High Lights of the Dinner

The speaking program will be much briefer than that at last year's dinner, but the address of Dean Willits on the integration of textile manufacturing and merchandising, in which he will present the first public explanation of the research now being financed by the Textile Foundation, and conducted under the supervision of U. S. Institute's Committee on Economic Research, will alone be worth attendance. President Garvan always has some important new subject to present, and, although he has not stated what is to be the subject of his introductory remarks as toastmaster, it will be surprising if he can refrain from mention of the wonderful reception that is being given throughout the country to his Farm Chemurgic Council—a scientific substitute for the A.A.A. The only other formal address will be that of Executive Vice-President Killheffer on "Why Textile Research?", and he has promised to handle this subject "without gloves." In between we shall hear a professional humorist who has the reputation of inspiring the "tired business

man," and there is a possibility of presenting one other feature of a vital and interesting character.

### Open Research Conference

While the greater part of the afternoon open research session will be devoted to a discussion of textile drying as affecting and affected by chemical processing, the features of the conference will be the presentation and explanation of the revised program for the textile drying study, and the address by Dr. Wanda K. Farr of Boyce Thompson Institute for Plant Research, Inc., on "A New Viewpoint in the Study of Cellulosic Textile Fibres." This conference, like its predecessors, is open to all who are interested, whether or not they are members of U. S. Institute, and members are urged to make this fact known and to invite guests.

The dinner, because of the fact that the economic study to be explained by Dean Willits is being conducted for the whole industry, is also open to all who may be interested, including ladies. This fact has been announced as widely as possible, but reservations may be secured until Tuesday, Nov. 3, by addressing the Secretary at his Boston office, and thereafter by addressing him at the Waldorf-Astoria. Tickets are $5.00 each. Dress may be of optional character.

Thursday, Nov. 5, is the date of meeting. The Waldorf-Astoria Hotel, New York, N. Y., is the place. An outline of the program is as follows:

### The Program

10:30 A. M., Crane Room, 4U.—**Meeting of Board of Directors.**

11 A.M. (Adjourned from 10 A. M.), Jansen Suite.—**Annual Meeting of Members** for presentation of formal reports and election of Directors.

12:30 P. M.—*Intermission for Luncheon.*

2 P. M., Jansen Suite.—**Open Research Conference.**

(1) Symposium on Textile Drying, sponsored by committee in charge: W. E. Emley, Chm., Alban Eavenson, Dr. H. DeW. Smith. The committee will present and explain the revised program for this research, and

will afford co-operators in the financing, and others interested, an opportunity to suggest changes or additions.

(2) Textile Drying and Chemical Processing. An open discussion of dyeing, printing and other chemical processing of textiles as affected by drying. Several authorities will be prepared to lead the discussion.

(3) Address by Dr. Wanda K. Farr. Subject: A New Viewpoint in the Study of Cellulosic Textile Fibres.

7 P. M., Jade Room.—**The Annual Dinner.** Preceded by reception in adjoining Basildon Room.

Toastmaster.—Hon. Francis P. Garvan, President, U. S. Institute for Textile Research, Inc., and The Chemical Foundation, Inc.

Address.—Dean Joseph H. Willits of Wharton School of Finance and Commerce, University of Pennsylvania. Subject: Survey of Production and Distribution Organization in the Textile Industry.

Address.—Mr. Francis J. Cooke. Subject: Adventures of a Professional Humorist.

Address.—Dr. Elvin H. Killheffer, executive vice-president, U. S. Institute for Textile Research, Inc. Subject: Why Textile Research?

# The Measurement of Color of Dyed Textiles

By R. D. NUTTING *

*Fellow of the Textile Foundation*

THE problem of color measurement and specification has become enormously simplified in recent years through the development of proper instruments. A broader understanding of their uses has been brought about through the publication of numerous articles in trade and scientific journals. It has been shown recently [1, 2] how measurements made with an instrument, such as the spectrophotometer, may be used to define exactly the color of any object in much the same manner as the eye would see it. By taking into consideration the type of illumination under which the object will be seen, three values known as Dominant Wavelength, Purity, and Brightness are determined. These values correspond physically to the more common concepts of hue, saturation, and brilliance, and are found to offer a convenient method for setting up limits of color tolerance.[3]

It has been established [4] that the sensitivity of the spectrophotometer exceeds that of the trained human eye for the detection of small color differences. Furthermore, the development of a photoelectric, recording spectrophotometer by Hardy [5] has placed on the market an instrument of the highest precision that presents complete results in the matter of only a few minutes.

The problem now confronting the color technologist is that of utilizing the measurements obtained with the spectrophotometer to the best advantage in his daily routine of work. Probably the most important question to a dyer is, "How much dye must I place upon a piece of material in order to obtain a definite color?" The answer to such an apparently simple question is not, unfortunately, so easy to obtain. Assuming, for the moment, that the complicated mechanical and chemical processes of placing the correct amount of dye upon the cloth are completely under the control of the dyer, there still remains the question of how many pounds of dyestuff on each pound of cloth will produce a certain color, or match a given sample.

It has been shown in a previous article [2] that two materials are a complete match in color when, and only when, their spectrophotometric curves are identical. It is frequently found that materials having different spectrophotometric curves match quite well under one particular source of illumination. But their fundamental dissimilarity is made painfully apparent when they are observed under different conditions of lighting. The problem, then, is limited to the process of obtaining a correlation between the amount of dyestuff on a known weight of cloth and the spectrophotometric curve of this dyed material.

This question of correlating the amount of dyestuff on cloth with the resulting spectrophotometric curve has been considered before and has been attacked

* Dr. Nutting, as a Senior Fellow of the Textile Foundation, worked under the direction of Prof. Arthur C. Hardy, Dept. of Physics, Massachusetts Institute of Technology, Cambridge, Mass.; present address: Krebs Pigments Department, E. I. du Pont de Nemours & Co., Inc., Curtis Bay, Md.

with some success by Shelton and Emerson,[6] Cohoe,[7] and Guelke and Fitzsimons.[8] The purpose of this paper is to show that the optical laws governing the absorption of light by transparent materials, such as clear dyestuff solutions, may be applied in an analogous way to the absorption of light by dyed textiles.

In the discussion that follows, it should be remembered that an object appears "colored" because some of the portions of the light that strike it are absorbed more than others. These portions of light are designated by their wavelengths and light of only one wavelength will be dealt with at a time. The laws applying to light of one wavelength (frequently designated as monochromatic light) apply equally well to light of any other wavelength in the visible spectrum.* Therefore, this restriction is no limitation to the use of these laws in a general way.

We will consider first the simple case in which light passes through a cell containing a solution of dyestuff, onto a piece of undyed cloth, as illustrated by Fig. 1. The portion of light that was not absorbed after passing through

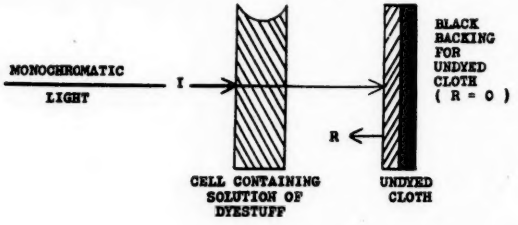


FIG. 1

the cell of dyestuff † and after having been reflected by the cloth is measured with the spectrophotometer and may be designated as R. If the amount of dyestuff in solution is changed, it is only natural to expect that the value of R will change accordingly. This we find to be true, and, as the concentration of dyestuff increases, the amount of reflected light, R, decreases. These changes have been measured with the spectrophotometer and are shown graphically in Fig. 2.

This diagram illustrates several things. It indicates that increasing the concentration of dyestuff decreases the amount of reflected light, and it shows also how each portion of the spectrum is affected by these changes in concentration. It is apparent that some portions of the spectrum are affected more than others, and for this particular dyestuff the wavelength of greatest change occurs at 510 mμ (millimicrons).

* The colors of light in the visible spectrum may be designated broadly by the following wavelength numbers:

| *Color* | *Wavelength* | *Color* | *Wavelength* |
|---|---|---|---|
| Violet | 400–450 millimicrons | Yellow | 570–590 millimicrons |
| Blue | 450–500 " | Orange | 590–610 " |
| Green | 500–570 " | Red | 610–700 " |

25,400,000 millimicrons = 1 inch.

† The dyestuff used in this experiment was National Aniline's Fast Wool Red GL and the cloth used in all experiments was #2511 gray obtained from the Arlington Mills. This cloth was chosen after much investigation because of its high degree of uniformity, evenness of weave, and absence of foreign matter.

This wavelength of maximum absorption or greatest change, 510 mμ, may be connected very definitely with the amount, or concentration, of the dyestuff present if a correction is made for the reflection of the undyed cloth. The measurements made with the spectrophotometer were so arranged * that the light lost by reflection and absorption of the cell containing the dyestuff was canceled out and may be neglected. For reasons that will be made clear later on, we are interested not so much in the light that is reflected or transmitted by our system shown in Fig. 1, but by the amount of light absorbed.

The amount of light incident upon the system is designated by I and the fractional quantity of light not absorbed by R. If $R_u$ denotes the light reflected by the woolen material alone, then the amount of light absorbed by the wool is $A_u$, equal to $(I - R_u)$; that absorbed by the entire system is A,

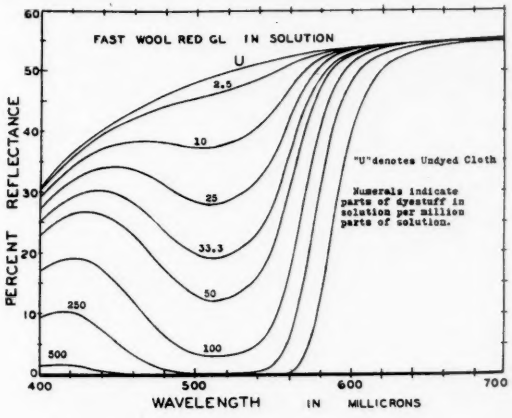


FIG. 2

equal to $(I - R)$. Since I represents all of the incident light, $I = 1$ and the following equations may be written:

Light absorbed by undyed wool alone $= A_u = 1 - R_u$, or $R_u = (1 - A_u)$.
Light absorbed by entire system $= A = 1 - R$, or $R = (1 - A)$.

The reflection of the entire system, R, may be expressed in terms of the concentration of dyestuff in the cell, C, by a simple expression known as Beer's law. However, it is first necessary to correct for the constant light absorption due to the undyed cloth, since the *percentage* of light reflected from it is unaffected by variations in the amount of dyestuff in the cell. The light transmitted by the dyestuff alone in solution in the cell is expressed by $\frac{R}{R_u}$.

* The Hardy spectrophotometer measures the diffuse reflection of an object relative to the reflection from a standard white magnesium oxide surface. The reflection and absorption of the cell may be canceled out, if so desired, by placing an identical cell filled with pure solvent in the path of the light beam that is directed at the standard white surface. This was done for the measurements discussed here.

This light is now related to the concentration of dyestuff by the following expression derived from Beer's law:

*Equation 1* $$\frac{R}{R_u} = e^{-kC}$$

where e is the base of natural logarithms (2.7183) and k is a constant depending only upon the dyestuff used and the thickness of the dye solution. In other words, for one dyestuff, such as Fast Wool Red GL, measured in a cell of fixed dimensions, k is a constant at a given wavelength and the only variables in the equation are R and C.

This equation may be transformed by taking the natural logarithm of both sides, giving:

$$\log_e\left[\frac{R}{R_u}\right] = -kC$$

Since: $$\log_e = 2.303 \log_{10}$$

Then: $$2.303 \log_{10}\left[\frac{R}{R_u}\right] = -kC$$

Or: $$-\log_{10}\left[\frac{R}{R_u}\right] = \left[\frac{k}{2.303}\right]C = KC.$$

Taking the common logarithm of both sides again, the following equation results:

$$\log_{10}\left[-\log_{10}\left(\frac{R}{R_u}\right)\right] = \log_{10} K + \log_{10} C.$$

Substituting now for R and $R_u$ gives:

*Equation 2* $$\log_{10}\left[-\log_{10}\left(\frac{1-A}{1-A_u}\right)\right] = \log_{10} K + \log_{10} C.$$

It should be possible now to plot $\log_{10}\left[-\log_{10}\left(\frac{1-A}{1-A_u}\right)\right]$ against $\log_{10} C$ and obtain a straight line relationship. This has been done in Fig. 3 for the maximum absorption at 510 m$\mu$ and the adherence to Beer's law is observed to be nearly perfect.

The same reasoning may be applied, it will be recalled, to measurements made at any other wavelength. The other three curves in Fig. 3 bear out this statement quite consistently, and we have now a way of predicting the amount of light absorbed at any wavelength for any concentration of dyestuff. In other words, spectrophotometric measurements are made at one concentration of dyestuff for as many wavelengths as are necessary to define the shape of the spectrophotometric curve. Beer's law is applied as shown above and the spectrophotometric curve at any other wavelength may be calculated directly. The simplest way in which to perform this computation is, perhaps, to construct a graph such as that shown in Fig. 4 and to place on it the point represented by the value of $\log_{10}\left[-\log_{10}\left(\frac{1-A}{1-A_u}\right)\right]$ measured at the known concentration $\log_{10} C$. A straight line is then drawn through this point with a

slope of 45°. By reading the value of $\log_{10} C$ on the abscissa for any other concentration of dyestuff, C, the value of $\log_{10}\left[-\log_{10}\left(\frac{1-A}{1-A_u}\right)\right]$ may be read directly on the ordinate as illustrated by Fig. 4. In order to avoid experimental error, it is better to measure the absorption at two concentrations covering the desired range and to construct Fig. 4 from these two points.

We are now in a position to study the practical case in which swatches of wool were dyed with various dyestuffs. The method of correlation previously

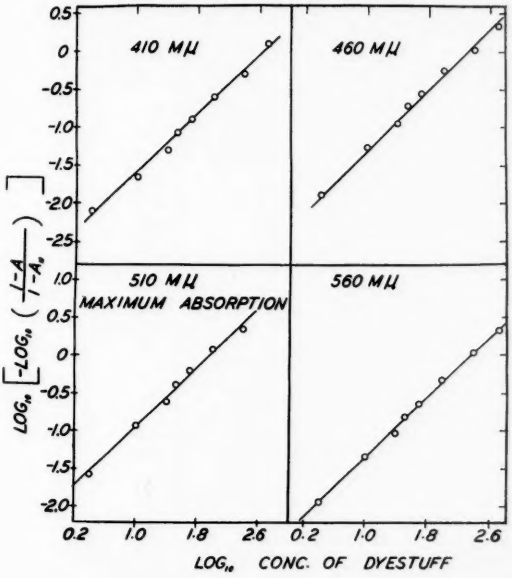


FIG. 3

discussed in connection with dyestuff solutions will be shown to be valid for measuring the amount of light absorbed by varying amounts of dyestuff placed on the cloth. It was intended, at the start of this study, to measure the reflection of light from an infinitely thick layer of dyed material, produced by folding the cloth sufficiently so that no light penetrated through the last fold. This plan was abandoned when it was found that the amount of light reflected from a pile of undyed woolen swatches did not increase with an increasing number of swatches (increasing thickness of wool) in the manner predicted by theory. Calculations were made using the method outlined by Steele [9] and these results show graphically in Fig. 5 that the measured reflection was always larger than it should have been. This discrepancy may be attributed, in part,

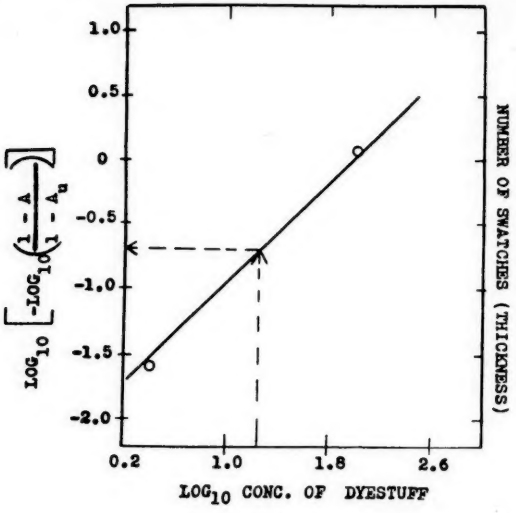
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
$\log_{10}\left[\frac{-\log_{10}(1-A)}{-\log_{10}(1-A_0)}\right]$
NUMBER OF SWATCHES (THICKNESS)
0.2
1.0
1.8
2.6
$\log_{10}$ CONC. OF DYESTUFF

FIG. 4

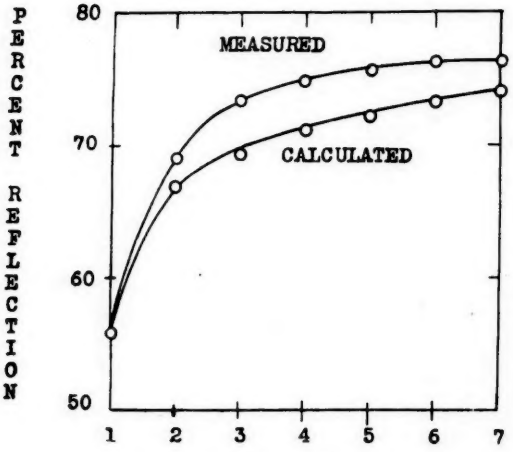
PERCENT REFLECTION
80
70
60
50
MEASURED
CALCULATED
1
2
3
4
5
6
7
Number of swatches (thickness.)

FIG. 5

to the non-uniformity of the medium, being composed of several layers of cloth rather than one homogeneous layer of increasing thickness.

The desire to avoid non-uniform and unlevel dyeing was another factor in favor of using a small sample of wool. Swatches two inches in diameter, weighing approximately 0.4 gram, were dyed by boiling with suitable amounts of dyestuff, Glauber's salt, and sulfuric acid in glass flasks. The dyed swatches were rinsed with cold water, dried, and measured for transmission and reflection with the spectrophotometer. The exhausted dyebath and rinsings were analyzed for unabsorbed dye by measuring the transmission of the solution spectrophotometrically and applying Beer's law. In this manner, the exact amount of dyestuff deposited on the wool was determined as the difference between the amount initially added to the dyebath and that remaining after the cloth had been removed.

Samples of wool were dyed with Fast Wool Red GL in concentrations from

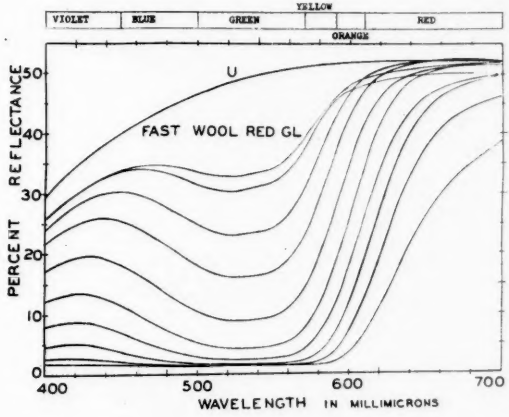


FIG. 6

0.0157% to 9.64% (grams of dyestuff per 100 grams of wool) and the reflections and transmissions from both sides of each sample were measured with the spectrophotometer. The reflection curves for all of the Fast Wool Red GL dyeings have been drawn in Fig. 6, starting with the undyed wool, designated "U," at the top of the figure, and descending the page in the order of increasing concentration of dyestuff. A set of spectrophotometric curves for the reflection and transmission of both sides of the sample dyed with 0.15% dyestuff are shown in Fig. 7. Similar spectrophotometric curves were measured for each of the other dyeings of this series and the average of the two curves was used in making the calculations.

The equation used earlier to correlate the fractional amount of light absorbed (at one wavelength) by a solution of dyestuff with the concentration of dyestuff in solution will now be applied, by making a minor change in one

of the terms. This earlier equation, it will be recalled, was:

*Equation 2* $$\log_{10}\left[-\log_{10}\left(\frac{1-A}{1-A_u}\right)\right] = \log_{10} K + \log_{10} C$$

where A = fractional amount of light absorbed by dyestuff solution and undyed wool backing, backed by black.

$A_u$ = fractional amount of light absorbed by undyed wool backing backed by black.

C = concentration of dyestuff.

K = constant, depending upon the nature of the dyestuff and the length of light path through the dye solution.

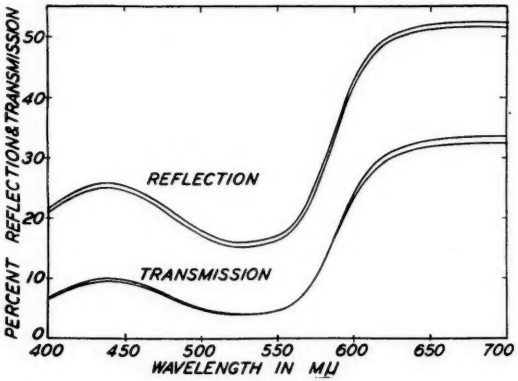


FIG. 7

The equation for expressing the amount of dye on the cloth in terms of the fractional amount of light absorbed by the cloth is:

*Equation 3* $$\log_{10}\left[-\log_{10}\left(\frac{1-\frac{A}{A_\infty}}{1-\frac{A_u}{A_\infty}}\right)\right] = \log_{10} K + \log_{10} C.$$

The symbols A and $A_u$ refer to the absorption of the dyed and of the undyed cloth, respectively, while C is the concentration of dyestuff, expressed as parts of dye per 100 parts of cloth. K has a similar significance as before, being a constant dependent upon the type of dyestuff and the length of light path through the dyed wool. The new term, $A_\infty$, refers to the fractional amount of light that would be absorbed if an infinite amount of dye were absorbed by the cloth. This term is, in reality, a correction for the surface reflection * of the cloth. It is determined by dyeing the cloth with successively

* Surface reflection occurs whenever light passes from one medium to another medium having a different index of refraction, such as in our present case, between air and wool. When discussing the earlier case of dye solutions it was unnecessary to consider surface reflection when light pased from air into the cell containing dye solution because, as was pointed out, a similar cell, containing solvent, was placed in the "standard" beam of the spectrophotometer. Thus all optical effects due to cell and solvent were canceled out.

increasing amounts of dyestuff until an additional small increase does not alter further the reflection of light from the sample as measured by the spectrophotometer. It is important that this correction for surface reflection be truly representative of the wool cloth and not caused by loosely held dye particles that are actually unabsorbed by the cloth. This is accomplished by measuring the values from which $A_\infty$ is computed near the wavelength of maximum absorption only.

The values of A, $A_u$, and $A_\infty$ of the equation are computed quite simply from measurements made directly with the spectrophotometer.

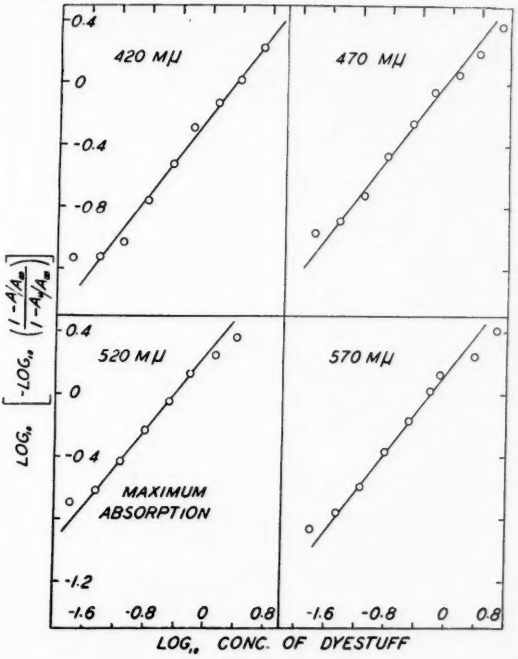


FIG. 8

A = 1 − (R + T), for cloth dyed at concentration, C.
$A_u$ = 1 − ($R_u$ + $T_u$), for undyed cloth, where C = zero.
$A_\infty$ = 1 − ($R_\infty$ + $T_\infty$), for cloth dyed at concentration = infinity.
R = Fraction of light reflected by cloth when backed by a non-reflecting surface, for which R = zero.
T = Transmission of light through cloth.

Equation 3 has been plotted for dyeings made at various concentrations of Fast Wool Red GL and Fig. 8 illustrates the correlation obtained at four

wavelengths, 420, 470, 520, and 570 m$\mu$. The data are consistent for all except the values for 620 m$\mu$, which are shown in Fig. 9. The poor correlation in this case is readily understood by referring to Fig. 6. Here it is seen that in the orange and red portions of the spectrum, where little absorption occurs, no regularity is obtained for the light reflected from samples dyed with the smaller amounts of dyestuff. This phenomenon has been noted before,[3] but no explanation has been found as yet to account for this anomaly.

The wavelength of maximum absorption for wool dyed with Fast Wool Red GL is 520 m$\mu$, whereas it is only 510 m$\mu$ for the dyestuff in water solution. This shift in absorption maximum is a phenomenon characteristic of some

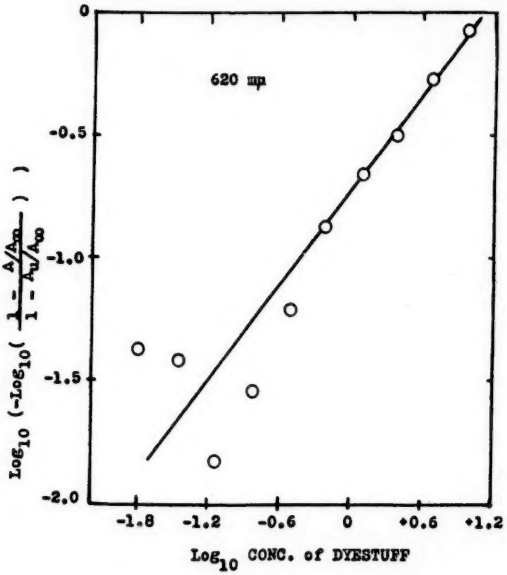


FIG. 9

dyestuffs and lead to the formulation of the so-called Kundt's [10] rule. This rule states that the absorption maximum of a dyestuff is shifted toward the longer wavelengths as the index of refraction of the dispersing medium of the dye is increased. However, as pointed out by Holmes,[11] the cases in which the opposite displacements occur equal in number those tending to uphold the rule and little credence can be given this hypothesis. Several other dyestuffs studied in connection with the present work exhibited the same wavelengths of maximum absorption in water solution and when applied to wool, thus bearing out Holmes' observations.

Dyeings have been made at various concentrations with several other woolen dyestuffs for the purpose of testing further the applicability of Equation

3. The reflection curves of each concentration series of these dyeings have been assembled on separate graphs and are shown in Figs. 10, 11, 12, and 13. The dyestuffs used were Wool Orange 2G crystals, Fast Light Yellow 2G, Alkali

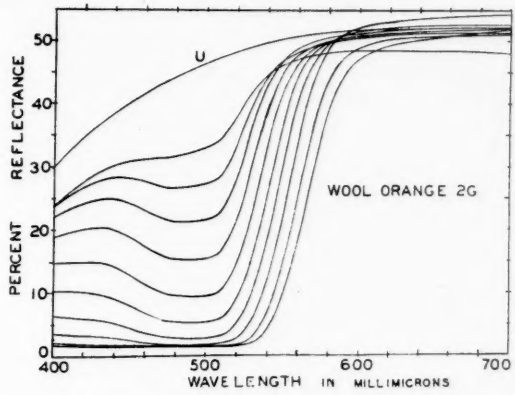


FIG. 10

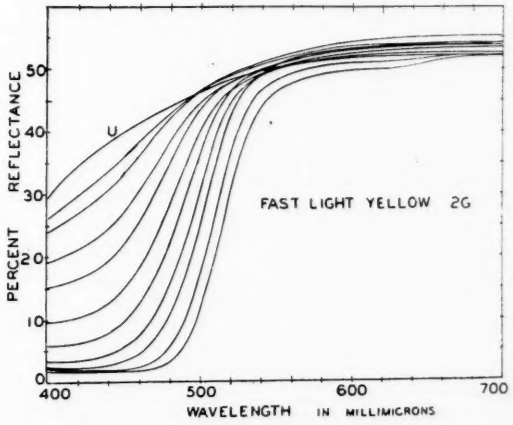


FIG. 11

Fast Green, and Acid Fast Violet BG. The reflections and transmissions were measured from both sides of the swatches dyed with these dyestuffs and the results averaged as described for the case of Fast Wool Red GL. Values of A, $A_u$, and $A_\infty$ have been calculated for the wavelength of maximum absorption

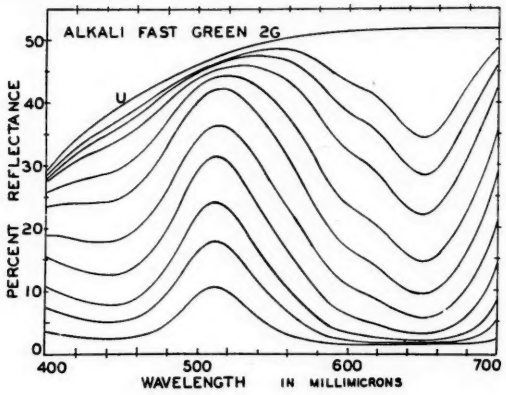


FIG. 12

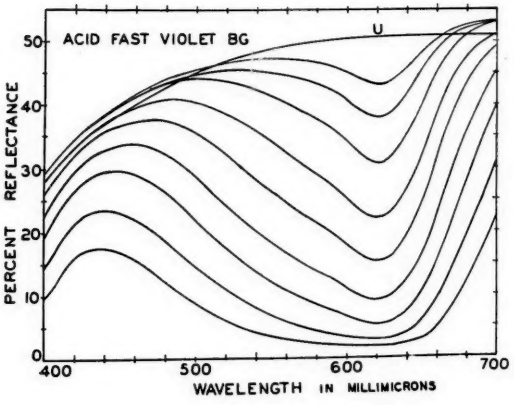


FIG. 13

of each of the dyeings and values of $\log_{10}\left[-\log_{10}\left(\frac{1-\frac{A}{A_\infty}}{1-\frac{A_u}{A_\infty}}\right)\right]$ have been plotted against $\log_{10} C$ in Fig. 14.

While it is felt that the method outlined here may be usefully applied to the problems of dyeing, it is realized that the measurement of both reflections and transmissions might be inconvenient. With this in mind a curve has been

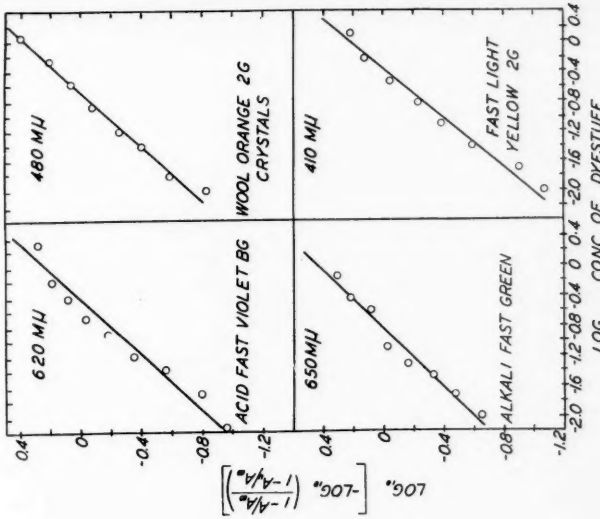
480 MU
WOOL ORANGE 2G CRYSTALS
620 MU
ACID FAST VIOLET BG
410 MU
FAST LIGHT YELLOW 2G
650MU
ALKALI FAST GREEN
LOG CONC. OF DYESTUFF

FIG. 14

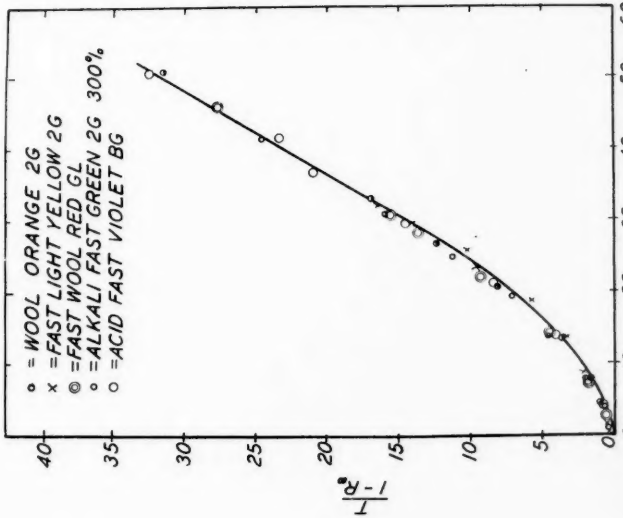
o = WOOL ORANGE 2G
x = FAST LIGHT YELLOW 2G
◎ = FAST WOOL RED GL
o = ALKALI FAST GREEN 2G 300%
○ = ACID FAST VIOLET BG
R - R∞

FIG. 15

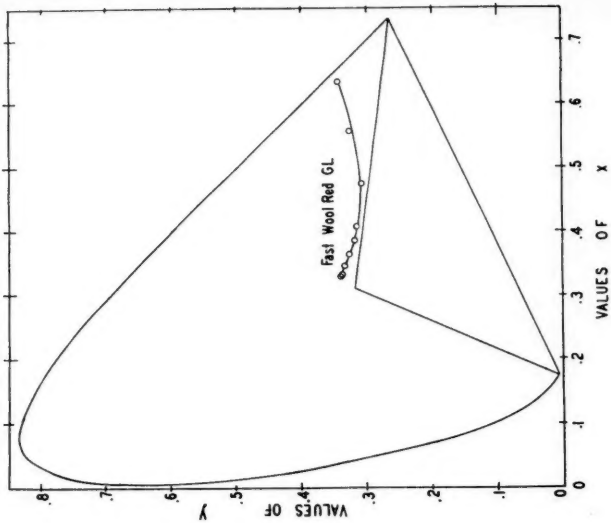
Fast Wool Red GL
VALUES OF Y
VALUES OF x

FIG. 16

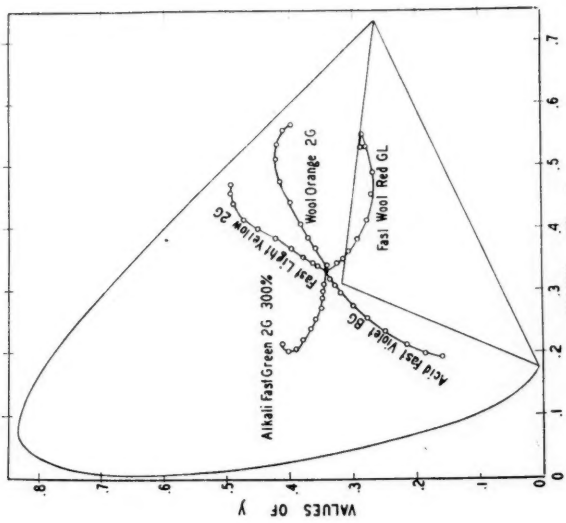
Alkali Fast Green 2G 300%
Fast Light Yellow 2G
Wool Orange 2G
Fast Wool Red GL
Acid Fast Violet BG
VALUES OF Y
VALUES OF x

FIG. 17

constructed from which the transmission of any dyed swatch (at the wavelength of maximum absorption) may be read if the value of the reflection is known. This curve, shown in Fig. 15, has been plotted from data presented graphically in this paper and has no established theoretical significance. It is quite probable that it would be necessary to establish a similar curve for each type of cloth to be studied. But once established, it would be valid for any dyestuff with which the cloth was dyed and would materially lessen the number of spectrophotometric observations.

The appearances of these dyed woolen samples under illumination approximating daylight in quality (I.C.I. Illuminant C) have been calculated in terms of Dominant Wavelength, Excitation Purity, and Brightness, and are summarized in Table I. These calculations were made by the procedure described in earlier papers,[1, 2] and the computations were greatly facilitated by utilizing the charts included for this purpose in the recently published "Handbook of Colorimetry." [12] The tristimulus values have been plotted on a Chromaticity Diagram in Fig. 16 (for I.C.I. Illuminant C) in order to show the progressive increase in Purity and change in Dominant Wavelength with increasing concentrations of Fast Wool Red GL solution backed by an undyed sample of wool. In Fig. 17 the various dyeings discussed in this paper have been plotted in the same manner and it is interesting to compare the curves of the red dyestuff in solution and when actually absorbed by the woolen cloth. The shift in the wavelength of maximum absorption toward the longer wavelengths noted earlier shows up here as having caused the dyed material to have a more purple appearance. In general, it may be observed from Fig. 17 that increasing the amount of dyestuff on the cloth above a certain amount does not make the color "stronger," that is, does not increase the Purity. It merely tends to shift the Dominant Wavelength toward the yellow-orange-red portion of the spectrum, with a marked decrease in brightness. This would be interpreted as a trend toward dull brown shades and is in good accord with actual dyeing results.

## Conclusions

An equation has been presented which, to a reasonable degree, correlates the concentration of dyestuff on cloth with the amount of light absorbed by the dyed cloth. This equation has been derived by analogy from certain well known relations applicable to the transmission of light through dyestuffs in dilute solutions. Five series of dyeings have been made under controlled conditions with dyestuffs representing the colors blue, green, yellow, orange, and red. The light absorption of these dyed materials has been obtained directly from transmission and reflection measurements made with the spectrophotometer and this data has been used to test the correlating equation.

This paper has been offered in no sense as the final word on the measurement of color in dyed textiles. It has been written, rather, with the hope that further work along these lines may be stimulated. The question of dyeing in mixtures of dyestuffs has not even been touched upon, and there still remains the puzzling anomaly of increasing light reflection in the red end of the spectrum with increasing concentrations of dyestuff. The trend toward large scale production with its inherent necessity of more accurate methods of control and closer tolerances is becoming of more importance daily. It is inevitable that some such methods of control will be adopted, and it is recommended that dyers, and colorists generally, avail themselves of the latest developments for the attack on problems of color measurement.

## Acknowledgment

The author wishes to express appreciation for the facilities placed at his disposal while conducting this work at the Massachusetts Institute of Technology. In particular, he wishes to acknowledge the assistance and cooperation of Professor Arthur C. Hardy and members of the staff of the Color Measurement Laboratory of M. I. T.

TABLE I

I.C.I. Illuminant C

| Dyeing % | Trichromatic Coefficients | | Dominant Wavelength mμ | Brightness % | Excitation Purity % |
|---|---|---|---|---|---|
| | x | y | | | |
| *Wool Orange 2G Crystals* | | | | | |
| 0.0102 | 0.3405 | 0.3442 | 579.2 | 45.21 | 15.9 |
| 0.01999 | 0.3688 | 0.3591 | 583.0 | 43.03 | 27.2 |
| 0.0394 | 0.3850 | 0.3712 | 582.0 | 42.22 | 34.9 |
| 0.0645 | 0.4080 | 0.3837 | 582.8 | 40.21 | 44.2 |
| 0.1358 | 0.4402 | 0.3978 | 584.2 | 36.22 | 56.8 |
| 0.274 | 0.474 | 0.4121 | 585.1 | 33.83 | 69.8 |
| 0.561 | 0.510 | 0.4182 | 587.0 | 30.65 | 81.0 |
| 1.080 | 0.534 | 0.4192 | 588.3 | 27.73 | 87.3 |
| 2.24 | 0.556 | 0.408 | 591.2 | 23.89 | 90.2 |
| 4.30 | 0.566 | 0.3952 | 593.5 | 20.91 | 89.8 |
| *Fast Light Yellow 2G* | | | | | |
| 0.010 | 0.3402 | 0.3558 | 574.0 | 51.34 | 18.6 |
| 0.0196 | 0.3443 | 0.3642 | 572.7 | 51.72 | 22.0 |
| 0.0397 | 0.352 | 0.380 | 572.0 | 50.49 | 28.2 |
| 0.0799 | 0.3668 | 0.3973 | 572.8 | 49.57 | 37.0 |
| 0.154 | 0.384 | 0.422 | 572.8 | 49.12 | 48.2 |
| 0.294 | 0.400 | 0.449 | 572.3 | 49.03 | 59.9 |
| 0.603 | 0.415 | 0.473 | 572.3 | 48.24 | 70.0 |
| 1.150 | 0.440 | 0.489 | 573.7 | 46.35 | 81.2 |
| 2.33 | 0.456 | 0.495 | 574.8 | 44.00 | 87.0 |
| 4.680 | 0.470 | 0.493 | 576.3 | 41.13 | 90.1 |
| *Fast Wool Red GL* | | | | | |
| 0.0157 | 0.343 | 0.324 | 596.0 | 38.36 | 11.0 |
| 0.035 | 0.349 | 0.318 | 610.0 | 36.78 | 11.0 |
| 0.0716 | 0.363 | 0.306 | 493.5 C | 32.36 | 14.0 |
| 0.150 | 0.382 | 0.292 | 495.0 C | 25.42 | 23.0 |
| 0.306 | 0.413 | 0.279 | 495.2 C | 18.46 | 34.2 |
| 0.595 | 0.455 | 0.271 | 494.7 C | 12.29 | 45.3 |
| 1.238 | 0.489 | 0.268 | 494.3 C | 8.82 | 53.0 |
| 2.408 | 0.531 | 0.279 | 492.9 C | 6.49 | 56.2 |
| 4.850 | 0.552 | 0.286 | 492.5 C | 4.53 | 57.6 |
| 9.640 | 0.529 | 0.288 | 492.5 C | 3.10 | 52.2 |

*Alkali Fast Green*

| | | | | | |
|---|---|---|---|---|---|
| 0.010 | 0.311 | 0.347 | 552.0 | 45.93 | 8.8 |
| 0.019 | 0.300 | 0.347 | 529.5 | 43.66 | 6.1 |
| 0.0347 | 0.288 | 0.348 | 509.5 | 40.27 | 7.5 |
| 0.0476 | 0.272 | 0.350 | 502.0 | 35.56 | 12.4 |
| 0.082 | 0.254 | 0.357 | 500.0 | 29.90 | 18.6 |
| 0.258 | 0.239 | 0.365 | 498.4 | 23.92 | 23.7 |
| 0.3745 | 0.221 | 0.379 | 499.6 | 17.62 | 29.8 |
| 0.710 | 0.206 | 0.388 | 499.5 | 12.27 | 34.8 |
| 2.015 | 0.202 | 0.401 | 500.6 | 8.49 | 35.6 |
| 3.135 | 0.213 | 0.411 | 503.2 | 4.85 | 31.7 |

*Acid Fast Violet BG*

| | | | | | |
|---|---|---|---|---|---|
| 0.007 | 0.318 | 0.336 | 566.0 | 46.24 | 7.3 |
| 0.021 | 0.309 | 0.330 | 547.0 | 44.05 | 3.5 |
| 0.043 | 0.294 | 0.320 | 496.5 | 39.85 | 5.7 |
| 0.064 | 0.275 | 0.302 | 497.5 | 33.15 | 12.8 |
| 0.125 | 0.255 | 0.279 | 482.5 | 25.77 | 24.0 |
| 0.211 | 0.232 | 0.248 | 479.6 | 18.60 | 36.0 |
| 0.368 | 0.212 | 0.214 | 476.8 | 12.78 | 47.6 |
| 0.642 | 0.198 | 0.185 | 474.5 | 7.77 | 56.2 |
| 1.975 | 0.193 | 0.158 | 471.0 | 4.55 | 62.3 |

## Erratum

The author wishes to take this opportunity for correcting several errors that appeared in the two previously published articles of this series.

The article titled, "The Objective Specification of Color," appearing in *Tex. Rsch.*, *6*, No. 1, Nov. 1935 contains an error on page 20 in that the multiplying factors for $\Sigma\bar{x}E_cR\Delta\lambda$ and $\Sigma\bar{z}E_cR\Delta\lambda$ were reversed. This should read, ". . . it is necessary to multiply $\Sigma\bar{x}E_cR\Delta\lambda$ by 0.9804 and $\Sigma\bar{z}E_cR\Delta\lambda$ by 1.1812 for Illuminant C." This error was carried through the worked example in Table I on page 19 and the multiplication of the sums and following computations should be changed to read as follows:

| | *Standard* | | *Offshade* |
|---|---|---|---|
| $0.9804\Sigma\bar{x}E_cR\Delta\lambda =$ | 717.5 | | 706.5 |
| $1.1812\Sigma\bar{z}E_cR\Delta\lambda =$ | 321.2 | | 188.0 |
| $(\Sigma\bar{x}E_cR\Delta\lambda + \Sigma\bar{y}E_cR\Delta\lambda + \Sigma\bar{z}E_cR\Delta\lambda) =$ | 1621.0 | | 1463.0 |
| $x = \left(\frac{717.5}{1621}\right) =$ | 0.442 | $\left(\frac{706.5}{1463}\right) =$ | 0.483 |
| $y = \left(\frac{582.3}{1621}\right) =$ | 0.359 | $\left(\frac{568.5}{1463}\right) =$ | 0.389 |
| $z = \left(\frac{321.2}{1621}\right) =$ | 0.199 | $\left(\frac{188}{1463}\right) =$ | 0.128 |
| $x + y + x =$ | 1.000 | | 1.000 |

These computation changes result in the following values of Dominant Wavelength and Excitation Purity in the table on page 10. The brightness values are unchanged.

| | *Dominant Wavelength* | *Excitation Purity* |
|---|---|---|
| Standard | 593.0 | 46.9 |
| Offshade | 589.6 | 65.9 |

Fig. 2 on page 11 was drawn from the previous erroneous data and should be disregarded entirely.

The article titled, "Color Tolerance: Its Measurement and Specification for Dyed Textiles," appearing in *Tex. Rsch.*, *6*, No. 2, December 1935, contains several errors in Table I on page 107.

The correct values that should be substituted in Table I are given as follows:

| Sample Designation | Tristimulus Values | | | | Trichromatic Coefficients | | Dominant Wavelength in Millimicrons | Excitation Purity in % | Brightness in % |
|---|---|---|---|---|---|---|---|---|---|
| | $\Sigma\bar{x}E_cR\Delta\lambda$ | $\Sigma\bar{y}E_cR\Delta\lambda$ | $\Sigma\bar{z}E_cR\Delta\lambda$ | Sum | x | y | | | |
| Pink | | | | | | | 500.6C | 5.77 | |
| " | | | | | | | 502.7C | 5.54 | |
| Black | 22.02 | 22.42 | 23.82 | 72.56 | .303 | .309 | 477 | 3.5 | 2.24 |
| " | 24.32 | 24.24 | 30.89 | 79.45 | .306 | .305 | 563C | 4.7 | 2.42 |
| Navy | | | | | | | | | 3.01 |
| " | | | | | | | | | 3.60 |
| C | | | | | | | | | 6.27 |
| " | | | | | | | | | 6.36 |
| D | | | | | | | | | 1.90 |
| " | | | | | | | | | 2.03 |

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*"Money without mind is inert. Industries without research are in peril. Brains without budgets can no longer conduct research on the scale demanded for prosperity of business and security of credit."—Popular Research Narratives.*

# An Outline of Some Fundamentals of Textile Physics

By DR. IRVING J. SAXL

*This paper attempts to discuss some of the fundamental phenomena underlying the physical analysis of textile materials as far as their mechanical properties are concerned. While the significant, mechanical terms used in physics and the engineering sciences have been found of practical value in other fields of applied physics such as electricity (the manufacture of electric cables) or mechanical engineering (wire rope), no full use of their potentialities has been made in textile research as yet. A discussion of some of the basic concepts is therefore, perhaps justified, particularly in view of the fact that* ***textile materials are primarily physical materials.*** *Such terms as tensile strength, percentage elongation, index of refraction, elasticity, etc., have been recognized for a long time in the textile industry. In the work with textile materials, an understanding of some of the physical phenomena underlying many textile problems will be found helpful.*

IT appears to be simpler for many other fields than that of textiles to establish precise physical terms, since the investigated objects of the former are more specifically defined. In a cable, for instance, the individual wire has a round cross-section, while in a yarn the individual filament has an irregular cross-section. In the final analysis, however, the average measurements obtained over a sufficient number of wires or for a representative number of yarns are comparable and reproducible. In one of the simplest examples, the weight of one foot of cable is reproducible, and so is the unit length of a piece of yarn, regardless of the cross-sectional shape of the individual filament of the latter.

If a cylindrical body has the length. L, the density, d, and the diameter, D, then its total weight, W, can be expressed by the formula

$$W = dL\left(\frac{\pi D^2}{4}\right) \qquad (1)$$

This is true for *any* physical body and accordingly is valid for a yarn the average cross-section of which remains constant, as well as for any substantially cylindrical object. While, however, the weight of long metallic cylinders, such as a single wire in a cable, is expressed in pounds per foot or kilograms per meter, the customary unit of description in the case of textile materials is *yards per pound.* (This is a linear function of denier.) The formula (1) is, however, more exact than the ex-

pression, "yards per pound of a material." Formula (1) expresses, among other things, the fact that the density of a material influences the yardage. Obviously this formula contains a parameter to measure the total material consumption in terms of density of the raw material.

It should be mentioned that the expression, d, for the density of the material has a meaning beyond the specific gravity (different for different materials). It is possible that for chemically identical materials the density, d, might be slightly different. The apparently slight change in density, however, may go in parallel with such a rearrangement of the micellar structure that the physical characteristics of the body under investigation may be changed substantially. The increased density of a hard-drawn steel wire may be only slight, although the tensile strength of this wire may be many times that of the original, soft untreated wire. *The density, d, is not only significant for different chemical compositions, but at the same time contains a factor which is characteristic of the physical condition of the material.* The question of molecular constitution and mutual submicroscopic arrangement is partially reflected in the parameter "d."

The question of varying density under different stretch has a particular significance in textile physics as it influences a factor of specific importance in the textile field. Reference is made here to the fact that the helical structure, imparted to the yarn by the twist, acts as a compressing force if the yarn is stretched. The filaments are pressed upon each other in accordance with the total load upon the yarn and in relation to the number of turns per unit length of yarn. Accordingly, the load under which a twisted piece of yarn is packaged or tested, influences the material constants to a certain extent.

A physically defined body, such as the previously mentioned cylinder, has a limited tensile strength. It is dependent among other factors upon its cross-section. The ultimate tensile strength can be expressed by

$$T = t\left(\frac{\pi D^2}{4}\right) \tag{2}$$

where

T = ultimate tensile strength.
t = tensile strength in units of force per unit of cross-section area.

This is internationally standardized in terms of kilograms per square centimeter [Kg./cm.$^2$].

It should be noted that, before the material finally separates, the area at which the separation will take place becomes smaller, and the material starts to "neck-down." Accordingly, the *ultimate total strength* in tension is not necessarily the *maximum tensile strength* per unit of cross-section. For many wires, for instance, the final rupture occurs at a lower ultimate strength per unit of cross-section than the maximum tensile strength that the material is capable of withstanding. The ultimate strength may then be defined as the greatest load that a material is capable of sustaining. This is somewhat dependent upon the *rate of load application* which, in the case of determinations for the ultimate strength, must be increased gradually until the material is ruptured. In this definition there is contained the question of the rate of speed.

Most bodies deform under the influence of physical forces. Such deformation is comparable, to a certain extent, to plastic flow. As such, investigations of filamentous materials are closely related to rheological research. We will have to come back to this once more in discussing relations of load versus elongation, where plastic flow of the material is an important factor.

Total elongation is termed the increase of a certain length of material up to rupture, divided by the original length of the same material before it was stretched. It is expressed in terms of percentage elongation. It gives (generally) the index of ductility of the material. It has been mentioned here previously that the time factor plays an important rôle in the determination of the maximum elongation of a material.

Before the final rupture takes place, a characteristic reduction of the area at the cross-section occurs. This reduction of area in terms of a percentage of the total area which the material had before the reduction of its diameter is

$$R = \frac{A_1 - A_2}{A_1} \tag{3}$$

where

$R$ = percent reduction of area.
$A_1$ = cross-sectional area of the original piece.
$A_2$ = cross-sectional area of the broken test piece at the place of break.

The ultimate strength of any material may then be defined as the unit stress that has been developed in said material at the moment of rupture. The unit weight of a material of a given tensile strength, discussed in Formula (1) remains, therefore, in a definite relation to the ultimate total strength. By dividing Equation (2) by Equation (1), we obtain

$$\frac{T}{W} = \frac{t}{d} \tag{4}$$

It is interesting to note that *Equation (4) is independent of the diameter or the physical shape of the material* under investigation. Equation (4), therefore, has the advantage of great general validity, and, therefore, high applicability to a number of important problems in textile physics,—provided that "t" and "d" can be directly measured.

No perfectly elastic or perfectly rigid body is known to exist. Under the application of stress, deformation occurs. Such a deformation may be reversible to some extent. If the stress was small in relation to the material constants, the material is capable of recovering to its original dimension practically completely. This deformation is defined as *elastic deformation.* If, however, the material has yielded to such an extent to the applied stress that it cannot return to its original shape completely, then we speak of a *permanent deformation.*

The region of change from the elastic deformation to the permanent one is the limit to which a material can be stretched safely knowing that it will return to its original shape upon the removal of its stress. It can be stated as a rule that for stress below this region the deformation remains in a linear relation to the stress. This fact is called ***Hook's law.*** It is valid to an extent for stresses less than the elastic limit. While

the change from the elastic deformation to the permanent deformation is a relatively gradual one, it is assumed for practical purposes that such a change takes place at practically a single point which is called the *elastic limit.* Before this limit is trespassed, the material deforms as a rule but little per unit of applied force, and the deformation is linearly proportional to the applied force. Beyond this point, a relatively small increase of the load or the stress produces a substantial increase in deformation.

The ratio of stress to the strain below the elastic limit is called *modulus of elasticity.* The modulus of elasticity, E, is

$$E = \frac{PL}{Al} \tag{5}$$

where

E = the modulus of elasticity (kilogram per square centimeter).
P = force in kilograms.
L = original length in centimeters.
A = area of the cross-section in square centimeters.
l = distortion in centimeters.

The modulus of elasticity, E, thus expresses the ratio of stress to strain for the material as long as the limit of elasticity is not exceeded. For stresses below the elastic limit, the definition of the modulus of elasticity is simply the ratio of stress to the unit of distortion. Obviously, there are physical limits to this. If taken literally, the modulus of elasticity, according to the preceeding, could be defined as the stress which would produce an elongation of a length of the material equal to the original length of the material. It would have to be assumed that the material would have to retain its elastic properties up to that point fully elastically and without rupture. The condition that the material is not to be stretched beyond the elastic limit eliminates this.

Next to the modulus of elasticity, *Poisson's ratio* will be found valuable in dealing with the mechanical properties of textile materials. The definition of *Poisson's ratio* is the ratio of the relative change of diameter to the unit change of length, under a load which is applied along the length axis and which must not exceed the elastic limit. The total load divided by the area of cross-section normal to the direction of the load is the stress in a material in the case of either compression or tension.

The relation between stress and deformation in a material is represented, as a rule, in diagrams termed stress-strain curves, or load-deformation plots. For textile materials the term "Dynamic Characteristic" has been used recently. As a rule the deformation is given as it refers to the unit of length. Either the dynamic characteristic is the deformation under the influence of pounds per square inch or kilograms per square centimeter.

Areas of equal stress must not necessarily lie in one unique plane. From photo-elastic measurements it appears that areas of equal strain may not necessarily be distributed uniformly throughout the material while, according to the classic definition in giving the stress of a material, the theoretical assumption is made that the load is distributed evenly over the entire cross-section.

The ratio of stress to strain, as described above, is termed *Young's Modulus* (M). If the area, A, is acted upon by the force, F, normal to this cross-sectional area, A, then the stress is $\frac{F}{A}$. Furthermore, the expression for strain is given as $\frac{e}{L}$.

where

e = the elongation, and
L = the original length.

By dividing the stress by the strain, we arrive at an expression, M, for Young's Modulus,

$$M = \frac{FL}{Ae} \tag{6}$$

The relative influence of stress upon strain may be ascertained from stress-strain diagrams, as they are known, for metals as well as for textile materials.

The elastic limit of any material is the maximum stress to which this material may be put with safety; *i.e.*, that, upon release of the force which produces the stress, the material returns entirely to its original condition.

Inasmuch as the yarn should not be in the range of yielding, it has no engineering significance if only the maximum elongation and the maximum tensile strength are known in yarns that have a decided elastic limit. The instance of ideal elasticity while approached practically sufficiently near as to permit industrial determinations, does not exist. (Every material is subject to plastic flow, even stones or entire continents. In terms of deformation per unit of time such changes in the structural composition may be sometimes in terms of centuries, while in other instances an almost immediate deformation takes place. From a physical view point, however, both are comparable.)

For many materials, particularly those resembling acetate type yarns, there never exists an actual equilibrium of load versus elongation. Under an applied load the material deforms continuously. Such deformation, though, may be so slow that for practical measurements a status of equilibrium often may be assumed. Also, in other yarns, the yielding as such may *not* necessarily be a sudden one. In other words, under quasi-stationary conditions, the dynamic characteristic of the yarn need not necessarily be parallel to the abscissa of the diagram. Also the transition from the steep ascent to the rest of the stress-strain function may be a gradual one.

Furthermore, a phenomenon may take place that is somewhat comparable to the "cold working" noted particularly in metals, whereby the resistance to plastic flow is increased by the effect of the initial plastic deformation (stress hardening).

Last, but not least, it may be realized that from a physical viewpoint not only longitudinal flow takes place, but also that there is a component of shearing stress. Inasmuch as the yarn contains twist, this helical construction of the textile material tends, under stress, to introduce a component due to shear which is super-imposed upon the longitudinal stress. Accordingly the question of shearing stress, "cold working," and longitudinal deformation may assist in various combinations.

Also, from another view point, it is of importance to see the broad general meaning of the physical conditions discussed. As in pitch, certain solid materials are subject to a constant, although slow flow. In the investigation of a material of this type it is necessary to introduce an arbitarary time constant, so that analyses of such materials may be made, not only in terms of a given load, but also in terms of a given load applied during a predetermined time interval.

What is characteristic for a yarn or wire from an engineering view point, is the region before the yield point is trespassed. Obviously the maximum stress is far beyond the safe working elastic limit. Again, however, it should be realized that two possibilities must be taken into consideration. One is that the final breakage, although higher, is far beyond the safe working elastic limit. The other possibility is that by systematic stressing it is sometimes possible to rearrange the micellar structure within the fibre, and that, after repeated loadings and load removal, the safe working limit may be increased. It is for this reason that the stretch-spinning process has given us synthetic yarns of improved tensile strength, and it is for the same reason that the tensile strength of cold-drawn steel wire is in excess of an annealed wire of macroscopically similar appearance.

While the material is supposed to return elastically to its original form according to Hook's law, if the elastic limit has not been trespassed, the yield point may require an additional stress. It is termed then that yield occurs when without further increase in the load the deformation continues. While hard-drawn materials and glass fibres scarcely show any yield point, it is the more pronounced, the more ductile the material is.

It also should be noted that, while the terms previously described apply primarily to the deformation of a material under stretch, similar relations exist for compression or shear.

In compression and shear, as well as in stretch, the pretreatment of the material becomes of importance. Cold-drawn steel wire has physical characteristics that are definitely different from soft wire. By the same token, stretch-spun yarn has different characteristics from yarn that has been stretched first, wetted out thereafter and stretched again. Small amounts of impurities strongly influence such rearrangements of the molecular structure, and the conditions for equilibrium for differently tempered or differently stretched yarns present a problem of great scientific interest.

It has been shown previously that the working elastic limit can be increased by pretreatment. Such pretreatment can be systematic loading, and would load under definite humidity and temperature conditions, as is the case for textile yarns. Or it can go together with the rearrangement of molecular structure such as takes place in the physical treatment of certain metal alloys. The important fact from the engineering view point is that, by proper prestressing, the safe maximum working stress can be raised and thus the working elastic limit. Such conditions of pretreatment, however, are distinctly different for different textile materials. Rayons, including acetates each require specifically different conditions. If the conditions under which the processing of the material are to take place are thoroughly known and understood, it is often possible to improve the physical properties of the materials to be used by the practical application of the laws that have been discussed.

# Abstracts

**This section is compiled under the direction of the Committee on Abstracts and Bibliography: Prof. E. R. Schwarz, Chairman, M. W. Weiss, Dr. Irving J. Saxl and C. H. Clark.**

## I. Fibres (Synthetic and Natural) and Fibre Analysis

Acetate Yarn: Manufacture and Properties of. V. L. Bohnson. *Am. Dye. Rptr.*, June 29, 1936, P. 350–56.

Paper presented at meeting, Northern New England Section, A. A. T. C. C., April 3, 1936. (C)

Cellulose: Modifications of. S. M. Neale. *Am. Dye. Rptr.*, June 1, 1936, P. 287–89.

Indicates that a more precise knowledge of cellulose may result from closer study of the hydro- and oxy-celluloses. (C)

Colloidal Aspects of Cellulose. Ben W. Rowland. *Paper Trade J.*, Sept. 26, 1935, P. 98–100; Abs., July 30, 1936, P. 31.

A survey of recent work on selected topics concerning the colloidal behavior of cellulose as related to technical problems of paper making, with bibliography of 34 references. (C)

Cotton Fibre: Influence of Heat and Humidity on the. E. Meissner. *Deut. Wollen Gewerbe*, 1936, V. 68, P. 603.

The amts. of oil in the seed and fibre varying with the season and the state of ripeness. If much oil is present, it is necessary to use higher temps. during the spinning of fine yarns as the oil tends to become solid, hard and gummy at lower temp. The gradual evapn. of the volatile fraction of the oil leaving a residue which becomes thicker and harder is responsible for the fact that the cotton obtained at the end of the season is not as good as the product at the beginning of the season. The natural gum of the cotton, corresponding to the formula is $C_{34}H_{24}O_4$, m. 86°, f. p. 82.5°. (From C. A., 1936, V. 30, Col. 4677.) (W)

Cotton Fibres: Degree of Maturity, Determination. A. P. Sakostschiffoff. *Faserforschung*, 1935, V. 12, P. 22–31; *J. T. I.*, April 1936, P. A179.

A description is given of a method for determining the degree of maturity of cotton fibres based on the capacity of the dry fibre, on swelling in an alkali solution, to regain its original cylindrical shape. (C)

ELASTIC PROPERTIES OF THE WOOL HAIR. H. Mendrzyk. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 119–21; *C. A.*, 1936, V. 30, Col. 3244. (W)

HEMP AND FLAX SPINNING MILLS: APPLICATIONS AND UTILIZATION OF WASTES IN. H. Rehmann. *Monatschr. Textil-Ind.*, 1935, V. 50, P. 292–3.

A description of various mech. and chem. treatments yielding a fine, white product free from visible contaminations which can be utilized as a raw material for manuf. (From *C. A.*, 1936, V. 30, Col. 2390). (W)

MICELLAR STRUCTURE AS RELATED TO CELLULOSE. James W. McBain and Daniel A. Scott. *Ind. Eng. Chem.*, 1936, V. 28, P. 470–3.

In a discussion of micellar structure and assocn. in relation to viscosity it is concluded: (1) Cellulose derivs. are assocn. colloids like soaps and assocn. and formation of micelles or more complicated structures appears to be an essential characteristic of cellulose and its derivs; (2) Staudinger's extrapolation procedure for detg. "mol. wts." from viscosity leads to erroneous values. (From *C. A.*, 1936, V. 30, Col. 3633.) (W)

NITROGENEOUS COMPOUNDS FROM COTTON AND LINEN: STUDIES OF. Franz Barlet. *Monatsh. Seide Kunstseide*, 1936, V. 41, P. 25–31.

A critical review. In spite of the work of Chilikin (cf. *C. A.*, V. 24, P. 3375) the characters of the "black acid" and the "amino acid L" have not yet been explained. (From *C. A.*, 1936, V. 30, Col. 2012.) (W)

OILING OF WOOL. Rinoldi. *Boll. laniera*, 1934, V. 48, P. 231–5.

The oleins should be free from oilve oils, metals and $H_2SO_4$, and have not more than 1% of unsaponifiable matter, sapon. value 197–203, I value about 84. (From *C. A.*, 1936, V. 30, Col. 3652.) (W)

RAMIE CELLULOSE: REFRACTIVE INDEX AND MOISTURE CONTENT. Madeleine Meyer and A. Frey-Wyssling. *Helv. Chim. Acta*, 1935, V. 18, P. 1428–35.

The authors criticize Kanamaru's studies on the refractivity of moist ramie fibres on the score that he allowed imbibition of the immersion medium by the fibre and thus really measured the index of the cellulose rather than the cellulose-water system. New data are now tabulated for the index of refraction and double refraction of ramie containing 0–17.3 wt.-per cent of water (0–24.4 vol.-per cent) as measured immediately (by "immersion") and after two days (by "imbibition") the immersion medium being a series of mixtures of amyl and cinnamyl alcohol. (From *J. T. I.*, April 1936, P. A179.) (C)

## II. YARNS AND FABRICS

ISOLATION OF LONG SILK FILAMENTS. Thos. Lonsdale. *Silk J.*, 1935, V. 12, No. 139, P. 39.

A method is described of obtaining cocoon threads and single ultimate filaments of silk in long lengths. (From *C. A.*, 1936, V. 30, Col. 1235.) (W)

MOISTURE-CONTENT: CONTROL OF—IN PAPER UNDERGOING THE PROCESS OF PROGRESSIVE DRYING. Jos. A. Sheehan. *Paper Trade J.*, Mar. 26, 1936, P. 37–9.

The author explains a new method of determining and controlling the amount of moisture in paper as it leaves the drying process. It is based on the fact that after a certain stage of drying has been reached, the increasing sheet temperature is a function of decreasing moisture content. The rate of evaporation during the various stages of drying is visualized by means of curves. Typical graphical records of moisture content as determined by this method are also shown. (C)

OXIDATION OF WOOL. Arthur Smith and Milton Harris. *Am. Dye. Rptr.*, April 6, 1936, P. 180–5.

The Effect of Hydrogen Peroxide. Data are presented on the effects on wool of varying the concentration, temperature and pH of the hydrogen peroxide solutions and the duration of treatment. The main point of attack during oxidation is the disulfide group of the cystine in the wool. The extent to which the wool is oxidized bears a functional relationship to the decrease in the cystine content and to the increase in the alkali-solubility of the wool. This is the first paper of a series on studies relating to the oxidation of wool.

The Lead Acetate Test for Hydrogen Peroxide-bleached Wool. The degree of darkening of the wool during lead acetate treatments is a function of pH, the maximum difference between untreated and bleached wool occurring at pH 5. The results indicate that hydrogen peroxide partially oxidizes the sulfur in wool and prevents the formation of lead sulfide. A mechanism by which lead sulfide is formed in untreated wool is described. (C)

PROCESSING AND WEAVING OF CUT RAYON STAPLE FIBRE YARNS. J. W. Pennington. *Tex. Mfr. (Rayon Supplement)*, May 1936, P. XXVII.

The spun rayon yarns provide an opportunity to cotton and other manufacturers. The weaving characteristics of the yarn are discussed in detail. (C)

RAYON: DESTRUCTION OF—BY MOLD, BACTERIA, AND INSECTS. (GERMAN.) S. Von Urban. *Die Kunstseide*, March, 1936, P. 90–5.

Rayon, like other textile fibres, is attacked by both mold and bacteria. The conditions under which rayon may be destroyed by mold or by bacteria are investigated. It is stated that acetate rayon resists the action much better than either the viscose or nitrate type. The development of fungi depends principally upon the humidity and temperature of the air, together with impurities on the fibre such as soap, alkali, starch, etc. For mixed tissues the possibility of reducing the damage caused by mold by means of suitable storage conditions is explained. As regard insects, it is pointed out that the moths' larvae cannot take rayon as food. Any damage observed in rayon tissue, then, are perhaps only slight and superficially formed. (S)

RAYON STAPLE FIBRE FABRICS: CREASING PROPERTIES. A Vogt. *Kunstseide*, 1935, V. 17, P. 459–62; *J. T. I.*, Feb. 1936, P. A58. (C)

RAYON STAPLE FIBRE: STAPLE LENGTH AND SPINNING. H. Esch. *Leipz. Monats. Text. Ind.*, 1935, V. 50, P. 77–8.

The most suitable staple length for staple fibre varies according to the type of yarn into which it is to be spun, the type of machinery on which it is to be processed, and the staple length of fibres with which it is to be mixed. Typical staple lengths for various yarns are given and the influence of the staple length on drafts and roller settings is discussed. (From *J. T. I.*, Mar. 1936, P. A105.) (C)

SILK: EFFECT OF DRY CLEANING AND OF WATER WASHING ON THE STRENGTH OF UNWEIGHTED AND OF TIN WEIGHTED. PAPER V, PART I. EFFECT OF DRY CLEANING, STAINS, STAIN REMOVAL AGENTS AND PRESSING. Pauline B. Mack and Elizabeth C. Ramsay. PART II. EFFECT OF VARIOUS DRY CLEANING SOLVENTS ON UNWEIGHTED AND ON TIN WEIGHTED SILKS. Pauline B. Mack and Mary Deck Hale. *Rayon & Mell.*, 1936, Mar., P. 36–8; April, 72–3. (C)

SILK: IRREGULARITY. W. Wagner. *Monatsh. Seide u. Kunstseide*, 1935, V. 40, P. 291–301, 340–6, 426–31, 462–72, 507–16.

Knots, corkscrews, thick and thin places, open threads, waste, loops and similar defects in raw silk threads are discussed and the origins of such defects are indicated. (From *J. T. I.*, Mar. 1936, P. A130.) (C)

SIZING OF RAYON YARNS. R. Hünlich. *Monatsh. Seide Kunstseide*, 1935, V. 40, P. 499–500; *C. A.*, 1935, V. 29, Col. 7665; 1936, V. 30, Col. 1569.

Rayon threads are sized with drying oils instead of starch and glue. (W)

SIZING: WHY—RESULTS ARE NOT UNIFORM. Edgar S. Genstein. *Kem Sizing News*, May, 1936, P. 7.

Emphasizes the difficulty of getting even impregnation of rayon warps on different slashers with identical sizing solutions, or on one slasher to get uniform results on every yard or on both sides of the same warp. Therefore, over-sizing of some ends is necessary to prevent undersizing of others. (C)

SOLUBLE STARCHES AND THEIR UTILIZATION. Gustav Durst. *Monats. f. Textil-Ind.*, 1933, V. 48, P. 193, 213; *Am. Dye. Rptr.*, Mar. 9, 1936, P. 138; Apr. 6, 1936, P. 172, 195.

The first part deals fairly fully with the distinctions between the various kinds of starches; the second part deals with the methods of preparation of the soluble starches. (C)

SPECIALIZED RAYON THROWING EVOLVES. *Rayon & Mell.*, May 1936, P. 37–9.

An experienced rayon man gives his viewpoint of the present status of rayon throwing methods. (C)

STAPLE FIBRE: PRODUCTION OF. H. Fischer. *Rayon & Mell.*, May 1936, P. 57–9. (C)

STRENGTH AND STRETCH IN COTTON YARNS. H. Pomfret. *Tex. Bull.*, 1936, V. 49, No. 18, P. 6, 9; *C. A.*, 1936, V. 30, Col. 1569. (W)

SYNTHETIC FABRIC TENSILE STRENGTHS. Anon. *Am. W. & C. Rptr.*, Mar. 19, 1936, P. 5–6, 10–11.

Describes a chart method of computing tensile strength of any synthetic yarn fabric when yarn strengths are known. A chart developed for viscose and acetate yarns (bright) of standard deniers and filaments is illustrated and explained. (C)

TEMPERATURE CONTROL IN WARP SIZING. A. W. Chase. *Rayon Warp Sizing Specialist*, April 1936. (C)

TENACITY OF CELLULOSE ACETATE IN VARIOUS FORMS. J. Allen. *Rayon & Mell.*, April 1936, P. 57. (C)

VISCOSE RAYON MANUFACTURE: USE OF CORN SUGAR IN. H. B. Vollrath. *Rayon & Mell.*, 1936, May, P. 60–1, 78; June, P. 35–7, 40. (C)

WARP SIZING: NEW LIGHT ON STARCH PROPERTIES AFFORDS OPPORTUNITIES FOR IMPROVEMENT OF. F. G. La Piana. *Tex. Wld.*, May 1936, P. 86–7; *Tex. Rsch.*, April 1936, P. 278–82.

This article is based on two technical papers, one delivered at the New Bedford Textile School, New Bedford, Mass., on Feb. 27; the other, at a meeting of Committee D–13, American Society for Textile Materials, held in Washington, D. C., on Mar. 12. (C)

WATERPROOFING: SOME RECENT DEVELOPMENTS IN. C. H. S. Tupholme. *Am. Dye. Rptr.*, April 6, 1936, P. 167. (C)

WATER-SOLUBLE RESINS AS SIZING AGENTS. (GERMAN.) Fritz Ohl. *Die Kunstseide*, March, 1936, P. 102–4.

The author describes the sizing agents successfully introduced during the last few years which are based upon high molecular cleavage product of protein. The advantages as compared with the older sizing agents are shown, and special directions for use of these new materials are given. Water-soluble resins are especially recommended for the sizing of the artificial fibres. Of the products concerned, glycolboriborate and complex boriphosphates of sodium have been tried as rayon sizes. Experimental results on the properties of such water soluble resins are added. Further, the absorption of these sizing agents by viscose and acetate rayon influence the mechanical properties of the fibres treated. The article concludes with a general comparison with the linseed oil sizes and the German conditions of raw materials are taken into consideration. (S)

## III. CHEMICAL AND OTHER PROCESSING (NOT OTHERWISE CLASSIFIED)

SOAP: COMPOSITION OF—AND ITS ACTION UPON TEXTILES. A. Lottermoser. *Angew. Chem.*, 1936, V. 49, P. 104–6.

A discussion of the effects of addn. of water glass to soap. (From *C. A.*, 1936, V. 30, Col. 2766.) (W)

SOAPS CONTAINING WATER GLASS IN THE TEXTILE INDUSTRY. A. Foulon. *Monatschr. Textil-Ind.*, 1936, V. 51, P. 104–5; *C. A.*, 1936, V. 30, Col. 4678.

The favorable influence of water glass on soaps and other detergents is due to the presence of OH ions in the washing liquor and the absorptive power of the colloids which causes them to absorb the dirt from the textile material. (W)

STABILIZATION OF DIAZO COMPOUNDS IN SOLUTION. G. J. Marriott. *J. Soc. Dyers Col.*, 1936, V. 52, P. 172–5; *C. A.*, 1936, V. 30, Col. 5041. (W)

STARCH AMYLASES: ACTIVITY MEASUREMENT. H. C. Gore. *Ind. Eng. Chem.*, 1936, V. 28, P. 86–8; *J. T. I.*, April 1936, P. A188. (C)

STARCH: DETERMINATION OF PASTING TEMPERATURE. F. Fischler and J. Schwaibold. *Biochem. Z.*, 1936, V. 283, P. 322–38.

A description is given of the use of the micro-melting point apparatus for determining the pasting temperature of a starch, defined as that temperature at which approximately 100% of the grains are in the swollen "pasted" state. Pasting temperatures are recorded and the effects of heat, grinding, etc., are noted. (From *J. T. I.*, April 1936, P. A192.) (C)

STARCHES: MICROSCOPY. O. A. Sjostrom. *Ind. Eng. Chem.*, 1936, V. 28, P. 63–74.

A series of photo-micrographs is presented showing the appearance of the more important starches and their modifications, the thin-boiling starches and dextrins, in their gelatinization and disintegration forms, the changes taking place in the configuration of the granules being demonstrated. Reference is made to the "growth structure" theory. (From *J. T. I.*, April 1936, P. A183.) (C)

STRUCTURE OF ANIMAL FIBRES IN RELATION TO ACID DYEING. J. B. Speakman. *J. Soc. Dyers Col.*, 1936, V. 52, P. 121–35; *C. A.*, 1936, V. 30, Col. 4325. (W)

SURFACE TENSION OF SOAP SOLUTIONS. N. K. Adam. *Faraday Soc. Trans.*, April 1936, 32.

The effects of slight traces of alkali in raising the surface tension of soap solutions are explained as due to suppression of hydrolysis, which is very much magnified in the surface layers, since the surface activity of the acid, or acid soap, is very much greater than that of neutral soap. The absorption of neutral potassium laurate is calculated from published data, and the absorbed film is found to be gaseous, of the usual type. (X)

TEXTILE FINISHING: PROGRESS REPORT IN THE FIELD OF—FOR THE YEAR 1935. K. Ullrich. *Wollen-Leinen-Ind.*, 1936, V. 56, P. 37, 50–2, 66–7.

A survey of articles and patents. (From *C. A.*, 1936, V. 30, Col. 4327.) (W)

TREATMENT OF FABRICS WITH UREA FORMALDEHYDE RESINS TO PREVENT WRINKLING. L. Molinari. *Materie plastiche*, 1936, V. 3, P. 11–16.

A review. After the treatment with compds. obtained by condensation with formaldehyde of mono- and dimethylolurea, the fabrics show an increase of wt. from 14.7 to 22.8% and an increase in the tensile strength from 25 to 53%. (From *C. A.*, 1936, V. 30, Col. 4328.) (W)

VAT COLOR PRINTING: SOME TECHNICAL ASPECTS OF. I. F. Chambers. *Am. Dye. Rptr.*, June 1, 1936, P. 289–94.

Paper presented at meeting, Textile Printing Colorists Guild, Inc., Paterson, N. J., May 16, 1936. (C)

VAT DYEINGS: DEVELOPMENT OF. Kurt Heide. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 133–7; *C. A.*, 1936, V. 30, Col. 3241.

The chemistry of vat dyeing is reviewed. (W)

VAT DYES OF THE BENZANTHRONE SERIES. XV. SYNTHESIS OF 5-METHOXYBENZANTHRONE AND 5, 5′-DIMETHOXYVIOLANTHRONE. T. Maki. *J. Soc. Chem. Ind. Japan* 38, Suppl. binding, 1935, P. 630–6; cf. *C. A.*, 1936, V. 30, Col. 867, 2008. (W)

WATER-REPELLING IMPREGNATIONS: VALUE OF. Hans-Joachim Henk. *Monatschr. Textil-Ind.*, 1936, V. 51, P. 82–3; *C. A.*, 1936, V. 30, Col. 3653. (W)

WOOL: USE OF ALBUMIN CONDENSATES IN THE VAT DYEING OF. W. Michel. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 220–1.

Various advantages of the use of vat dyes over other dyes are described in detail. Among the new textile aids for vat dyeing operations are those consisting of combinations of high-mol. proteins with fat acids, such as *Lamepon A* manufd. by Chem. Fabrik Grünau. Sp. dyeing directions are given and several photographs show the improved uniformity of the dyeings and increased resistance to rubbing which was obtained by the use of this textile aid. (From *C. A.*, 1936, V. 30, Col. 4011.) (W)

## IV. RESEARCH METHODS AND APPARATUS

EMULSIFYING MACHINE. R. Auerbach. *Kolloid Z.*, March 1936, P. 74.

A new machine is described in which there is complete separation between the mechanism for moving the dispersing agent and that for bringing about the dispersion. (X)

FALLING SPHERE VISCOMETER: WALL CORRECTION. E. I. Fulmer and J. C. Williams. *J. Phys. Chem.*, 1936, V. 40, P. 143–49.

An equation is derived by means of which the wall correction for the falling sphere viscometer can be made for values of the ratio of the radius of the sphere to the inside radius of the cylinder, $r/R$, up to about 0.500. (From *J. T. I.*, April 1936, P. A192.) (C)

FATIGUE TESTS WITH THE UNIVERSAL YARN-TEST MACHINE ACCORDING TO THE SYSTEM OF DR. FRENZEL-HAHN. A. Grote. *Spinner u. Weber*, 1936, V. 54, No. 17, P. 3, 5–12.

Tests on the detn. of the properties of yarns should include not only the yarn no. and uniformity but also the resistance to tear. The data obtained usually do not include the elongation, an important property, which cannot be detd. as readily and accurately as the strength by most devices. The new testing machine which handles this problem readily is described, and fatigue curves detd. with it are given for a variety of materials. (From *C. A.*, 1936, V. 30, Col. 4328.) (W)

FIBRES: TESTING THE FLEXURE BREAKING STRENGTH OF. E. Franz and H. J. Henning. *Mell. Textilber.*, 1936, P. 120.

The quality of textile materials is usually tested by means of their breaking strength and their breaking elongation. Although these testing methods are of great value for spinners and weavers, they yield no information about the wearing qualities of a fabric, from which point of view instruments have already been constructed for testing fabrics by abrasion. That method, however, is not of itself decisive, because a fabric is treated differently by the abrading machine than by ordinary wear. The authors accordingly recommend the application of the flexure breaking strength test to complement the abrasion test. For that purpose they have designed an instrument which consists mainly of an oscillating clamp into which the fibres are fastened under various loads. Normally, the fibres are bent about 200 times per minute and a simple reliable recording motion is provided which determines the number of flexures required to break the fibres. The results of the tests are not evaluated by the ordinary arithmetical average mostly used, but by the geometrical mean which is calculated from the mean of the logarithms of the individual flexure numbers. (C)

GELATIN SOLUTIONS: PH MEASUREMENT. I. Petrov and A. Pasuinskii. *J. Appl. Chem., U. S. S. R.*, 1935, V. 8, P. 165–70 (through *C. A.*, 1935, V. 29, Col. 6817); *J. T. I.*, April 1936, P. A188. (C)

MEASURING WOOL DAMAGE: MODIFIED METHOD FOR—DUE TO SCALE BREAKAGE. James H. Kettering. *Rayon & Mell.*, June 1936, P. 49–50.

Experiments disclosed that room temperature is the chief factor influencing results of the Rimington-Pauly test for wool damage. The proposed method specifies a constant laboratory temperature and substitutes simpler procedures for more difficult manipulations. Using this modified procedure, reproducible results were obtained from fabrics both slightly and extensively damaged. The values obtained when correlated to the strength index show a linear relation between the results of the revised test and of a physical measure of deterioration. (C)

MICRO-KJELDAHL METHOD IN THE ANALYSIS OF SILK THREAD AND TEXTILES. M. Bonicatti. *Boll. ufficialle R. staz. sper. seta*, 1934, V. 4, P. 35–7.

A semimicro method is described. (From *C. A.*, 1936, V. 30, Col. 3243.) (W)

PULP BLEACHING SOLUTIONS: SIMPLIFIED METHOD FOR THE RAPID DETERMINATION OF THE AVAILABLE CHLORINE CONTENT OF. Donald T. Jackson and John L. Parsons. *Paper Trade J.*, Aug. 13, 1936, P. 77–8.

For determining the available chlorine content of hypochlorite solutions in the control of pulp bleaching the method of Pontius has been modified to include an inside indicator so that only a single reagent is employed by the operator. The procedure is simple and rapid and has been successfully employed in a pulp mill for several years by mill operators. Comparative analyses of a series of hypochlorite solutions using the arsenite method and the Pontius method show good agreement between the two. (C)

SPIERER LENS: APPLICATION. W. Seifriz. *Ind. Eng. Chem.*, 1936, V. 28, P. 136–40.

The application of the Spierer dark-field lens is discussed with particular reference to its utilization in cellulose research. Various criticisms of the validity of its pictures are answered. If suitable material is used, and the optical system properly handled, the pictures of colloidal matter it affords represent a true structure. The major types of structure observed have been seen by several other methods. For example, recent X-ray work on cellulose gives evidence of a structural unit comparable in size to the supermicelles shown by the Spierer lens. (From *J. T. I.*, April 1936, P. A178.) (C)

STARCH VISCOSITY. Thomas H. Hart. *Am. Dye. Rptr.*, June 15, 1936, P. 313–15.

A general survey of four methods in use today for the determination of viscosity of starch and starch products. Many laboratories have made the mistake of reporting their results of viscosity as merely seconds, which to the next laboratory means absolutely nothing, but where specific viscosity is used, a definite standard is established which can be understood by all. The newer idea is to express all results in the terms of the absolute unit, the Centipoise. This unit is finding more and more use every day. It is possible to obtain standard solutions to time in any viscometer regardless of type so that by calculation of the time required for the standard solution to pass through the viscometer, direct readings in centipoise may be obtained. The latest and one of the finest of viscometers is the Hoeppler type which operates on the principle of the falling ball and all readings are directly expressed in centipoises. Other types of viscometers used most generally are the Dudley Tube, also the Drucker and Ostwald Tubes, the Stormer, Saybolt, Engler and Perkins. All of these viscometers can be used to obtain specific viscosities and by use of standardized solutions, readings can be calculated directly to centipoises. For measurements of "jelly strength" as a form of viscosity as outlined under Method 3, a formula for conversion of these results must be obtained by the user to convert the arbitrary units of that form of viscometer to give results in centipoises. Here again a standardized solution could be used to establish the readings directly in centipoises. (C)

pH VALUES: DETERMINATION OF—BY THE HYDROGEN AND ANTIMONY ELECTRODES. A. T. Williamson and W. G. Oakes. *J. T. I.*, July 1936, P. T199–203.

A rocking hydrogen electrode, based fundamentally upon the Clark instrument, is used. The novel feature of the electrode model consists in

the use of an agar-potassium chloride bridge combined with a tap system of standard form, both of these simplifications permitting a reduction in the time required for manipulation as well as reducing the initial cost of the electrode. (C)

PROTEINS: PARTICLE WEIGHT AND SHAPE; DETERMINATION FROM DIFFUSION AND VISCOSITY DATA. A. Polson. *Nature*, 1936, V. 137, P. 740.

From a knowledge of the diffusion constant and viscosity of protein solutions it has been found possible to estimate molecular weight and shape. The equations on which the determination is based and results obtained for several proteins are given. (From *J. T. I.*, July 1936, P. A346.) (C)

QUALITATIVE ANALYSIS OF TEXTILES. G. S. Ranshaw. *Silk & Rayon*, 1935, V. 9, P. 746, 748–9.

Selected methods for identifying rayons, wool, linen, cotton and silk are described. Naphthylamine 4B stains viscose and cuprammonium rayons pale reddish gray and dark bluish gray, resp. Stains produced on all fibres are described in detail. (From *C. A.*, 1936, V. 30, Col. 5797.) (W)

SCIENTIFIC MEASUREMENT OF WOOL FIBRES. H. Rausch. *J. Bradford Tex. Soc.*, 1935–36, P. 70–80.

A description of apparatus developed at the Leipziger Wollkämmerei for testing the fineness of fibres, swelling, elasticity and whiteness of fibres and tops, evenness of yarns, and water absorption and wearing properties of fabrics. (From *J. T. I.*, July 1936, P. A336.) (C)

SORPTION OF WATER VAPOR ON CELLULOSIC MATERIALS. Edgar Filby and O. Maass. *Can. J. Rsch.*, July 1935, P. 1–10.

A direct method for measuring the adsorption of water vapor on cellulosic materials and in which a number of improvements were made is described. It is ensured that no vapors other than water are present no matter how long a time is required for the establishment of equilibrium. The adsorption and desorption isotherms of standard cellulose, spruce wood, surgical cotton, Kodak rag cellulose, and bleached sulphite were measured, and the data which indicate the time required for the establishment of true equilibrium are given. The data of Urquhart and Williams (*J. T. I.*, 1924, V. 15, P. T138–48; *Shirley Inst. Mem.*, 1924, V. 3, P. 49–307) for standard cellulose are shown to be correct. (From *Paper Trade J.*, Aug. 20, 1936, P. 31.) (C)

TESTING OF RAYON. H. Roche. *Silk J.*, 1936, No. 144, P. 17, No. 145, P. 28–9; *C. A.*, 1936, V. 30, Col. 5420. (W)

VISCOSE RAYON: LEVEL DYEING TEST. H. Schmidt. *Textilchem. u. Col.*, 1936, V. 17, P. 33–37 (Suppl. to *Deut. Färber Ztg.*).

Previous methods for testing the level-dyeing qualities of viscose rayon (Messrs. Courtaulds; Ratelade) are discussed and attention is called to a recent Russian method that depends on the stripping power

of 10% pyridine. From experience of the method the conclusion is drawn that a delivery of viscose rayon with a regularity 0.90 will be level-dyeing for all practical purposes, but a value below 0.85 gives rise to suspicion. (From *J. T. I.*, July 1936, P. A337.) (C)

YARNS: EFFECT OF REPEATED LOADING AND UNLOADING. H. P. Zoeppritz. *Textilber.*, 1936, V. 17, P. 301–2.

It is pointed out that ordinary strength tests do not give a satisfactory indication of the behavior of textile materials in use and investigations of the effects of repeated loading and unloading on cotton tire cords and similar cords made from wool are described. The results show that with repeated applications of the same load the total extension shown by a yarn remains practically constant but the permanent extension increases and the elastic extension decreases with increasing number of applications. The increase in permanent extension and decrease in elastic extension decrease with increase in number of loadings until an equilibrium state is reached after which further applications of the load produce only elastic extension. These results are explained by the assumption that the permanent extension is due to displacement of the fibre layers which results in a reduction in cross-section of the yarn while the elastic extension is due to the stretching out of the spirals formed in the twisting operations and to elastic extension of the constituent fibres. (From *J. T. I.*, July 1936, P. A338.) (C)

## V. ECONOMICS, PHYSICS AND MISCELLANY

CALENDERING OR DRYING OF MATERIALS. W. W. Spooner. Brit. pat. 436, 654, Apr. 16, 1934; *Paper Trade J.*, Aug. 27, 1936, P. 41.

Paper or the like is heated on one side by contact with a metallic surface (*e. g.*, a heated roll in a paper machine), and to the other side are applied a number of inclined jets of air at high velocity and at a temperature greater than that of the paper, the air being collected in a hood, reheated and used over again. (C)

DRYING OF PAPER: FACTORS OF IMPORTANCE IN THE. F. C. Clark. *Paper Trade J.*, Nov. 7, 1935, P. 33–5.

A brief discussion drawing attention to the importance of preventing the overdrying of paper at any stage in its manufacture and to the importance and difficulty of maintaining the correct moisture content. (C)

DRYING OF PAPER: SOME IMPORTANT FACTORS INVOLVED IN THE. F. W. Adams. *Paper Trade J.*, Dec. 12, 1935, P. 33–5.

A brief discussion of the principal factors affecting rate of drying, steam economy and completeness of drying. (C)